The Cost of Not Maintaining the Urban Forest

By Richard J. Hauer, Jessica M. Vogt, and Burnell C. Fischer

Objectives

- Identify the elements of an urban forest maintenance framework
- Describe components used in assessing the costs and benefits of urban trees
- Summarize thresholds for determining optimal pruning cycles
- Evaluate the link between tree maintenance activities and urban forest benefits

CEUs for this article apply to Certified Arborist, Utility Specialist, Municipal Specialist, Tree Worker Climber/Aerial Lift Specialist, and the BCMA management category.

Most people get excited with new things, like cars, buildings, and yes, newly planted trees. But what was once new, soon becomes old, and with age comes the question of maintenance. Preventive or proactive maintenance sets the stage to provide greater service life, and if done correctly, preventive maintenance should cost less than delaying maintenance. For properly planted and maintained trees, a greater, overall value of the urban forest is a likely result. Human nature, however, means that we may often ask: *Why maintain today what we can delay until another day?* Indeed, what's the worst that can happen—except, possibly, paying more later than what we would pay in the present.

A literature review of more than 300 papers on tree maintenance in the fields of arboriculture and urban forestry set out to answer the question: What are the costs of not maintaining trees and the urban forest? The literature review produced a detailed summary of 163 papers that discussed maintenance costs in the context of the benefits of urban trees and revealed how lack of maintenance impacts future value. Common urban forest operations (planting, pruning, removal, pest and disease management, and infrastructure repair) and other important activities affecting tree longevity (tree risk management, watering, mulching, nutrient management, tree support systems, and tree protection) were included in this study. The results shed light on our current state of knowledge of the economics of urban tree management, with emphasis on maintenance activities used to increase service life and provide greater, overall net benefits.

Urban Forest Maintenance

A framework for urban forest maintenance involves six elements (Table 1). The first element is the type of maintenance (e.g., pruning, nutrient management, removal); the

Table 1. Key elements of an urban forest maintenance regime.

Element	Description	Examples
Type	The particular maintenance activity	Prune, mulch, stake
Who	Party physically performing maintenance activity	City tree crew, contracted certified arborist, nonprofit, adjacent home owner
Intensity	How much	Ten percent of the crown, 5 (18.93) or 15 (56.78) gallons (liters) of water
Frequency	How often	A four- or six-year pruning cycle, once per week
Duration	How long	For just the first growing season after transplanting, throughout a tree's life
Extent	What part of a tree or which trees	Branches below 14-foot (4.27 m) clearance level, all trees in a city, trees on heavily traveled road corridors, trees in a downtown area

second element is who performs the maintenance activity (e.g., public, private, professional, citizen, nonprofit).

The next three elements recognize the intensity (how much), frequency (how often), and duration (how long) of the maintenance activities. Is the maintenance a one-time occurrence, or is it repeated? Pruning is an example of a type of maintenance with a frequency that might never occur, occur only at planting, or occur regularly on a periodic cycle (e.g., every four to six years). During each pruning, the intensity is the percentage of the canopy or leaf area that is removed (e.g., 10 percent to 20 percent), or more realistically, the branches selected for removal. The duration is how much time is spent pruning or when, during a tree's life cycle, the tree is pruned (e.g., structural pruning to train branch structure that occurs periodically during the establishment and immature phases).

The final element involves the extent of maintenance and could refer to activities such as vehicle clearance or pruning only in high-traffic areas. The extent could be phrased as an objective as part of a tree care standard practice.

Maintenance considerations ideally begin before planting. Selecting a plant that is compatible with a site helps prevent future conflicts requiring maintenance that could be avoided during the design phase. What initially occurs (or does not occur) at planting can greatly affect future maintenance, survival, and longevity of trees. During the life of a tree, it grows from immature to semi-mature, mature, and senescent lifecycle stages (Figure 1). During each of these stages, maintenance activities may increase the benefits that trees provide. Benefits increase as trees age to the point they become senescent.

Not performing maintenance can result in reduced benefits as well as tree populations of lower value (Miller and Sylvester 1981). Immature trees provide fewer benefits and have relatively greater costs (from planting and maintenance during establishment) than the benefits and costs associated with trees as they mature. As planted trees enter the first to second decade of life, the net benefits become positive, as benefits start to exceed the cost of maintenance as trees become semi-mature (McPherson et al. 1997). As trees mature they provide increasingly greater net benefits, which is the difference between the benefits and costs of an urban tree (VanNatta et al. 2012). Eventually, if trees survive long enough, they senesce as they age. At this stage, there are trade-offs: should we remove a tree or continue to provide increasingly greater maintenance to promote longevity and ensure citizen safety? A point is reached with senescent trees when maintenance costs exceed a tree's benefits, and retention of trees beyond this point becomes a monetarily irrational decision. However, these trees may have heritage and ecologic values that justify their retention. During all stages of a tree's lifecycle, providing

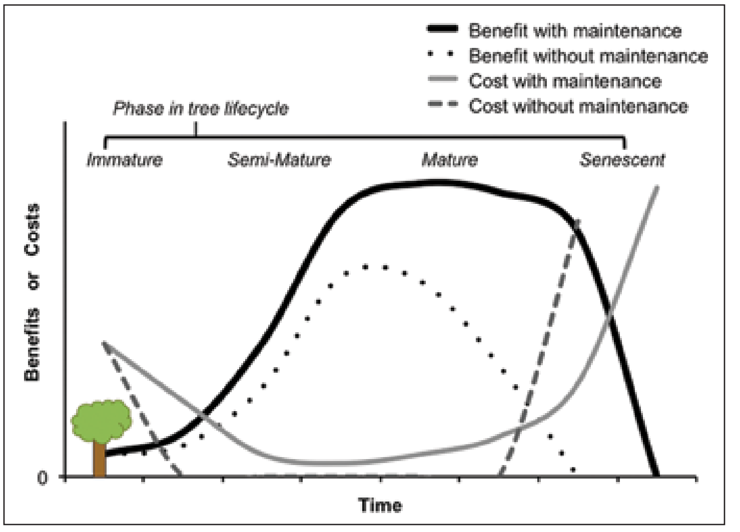

Figure 1. Theoretical costs and benefit profiles over the lifetime of an individual tree, with (solid lines) and without (dashed lines) adequate maintenance. Benefits are maximized during the mature phase of a tree and decline rapidly through senescence, while costs show an inverse pattern.

for maintenance that exceed the benefits is a financially inefficient means of allocating resources. The cost of not allocating resources for maintenance, when performing maintenance would have yielded net benefits, is an opportunity cost.

Linking Maintenance to Benefits and Costs

Trees provide many benefits to society (Roy et al. 2012). Many trees in built environments are the direct outcome of planned activities that result in planting trees. The initial investment in planting and maintaining urban trees is a cost incurred with the expectation of future benefits. Maintenance of tree populations is linked to tree structure and function, which benefits the urban forest (Figure 2). It is likely that benefits will accrue without maintenance; however, indirect costs and disservices may result from this lack of maintenance, including tree failures, debris, pests, branches blocking intersections, and other issues. Thus, urban trees frequently necessitate at least some level of tree maintenance in order to prevent conflicts with other urban infrastructure. Proactive (i.e., systematic) maintenance should also lead to more efficient tree management than reactive (i.e., crisis) maintenance.

The urban forest manager is tasked with applying a level of maintenance that optimizes the net benefits of tree populations. Allocation of maintenance resources (e.g., time, money, labor) below an optimal level results in a trade-off—potentially less healthy trees that may have a shorter life span or service life. Allocation of resources for maintenance in excess of what is needed also results in a lower net benefit. The question then becomes:

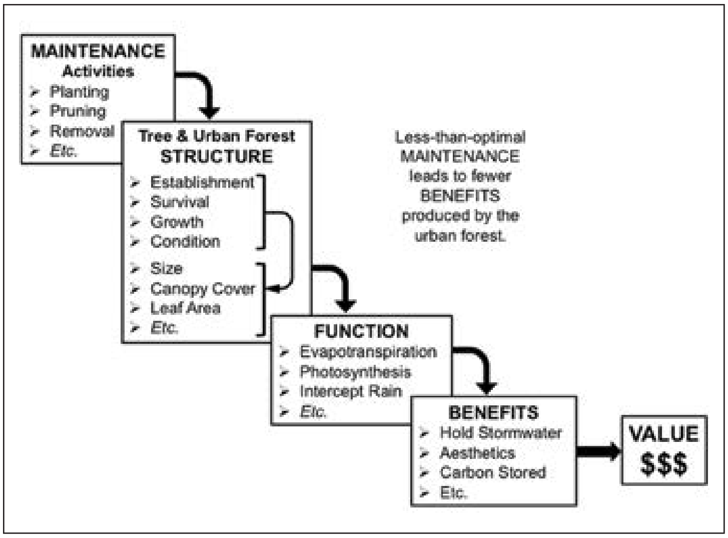

Figure 2. Maintenance directly impacts tree structure, which in turn impacts the functions and benefits provided by the urban forest.

What is an optimal level of maintenance? The literature provides some examples through studies with pruning, establishment, and pest management.

To Prune or Not to Prune

Miller and Sylvester (1981) demonstrated the concept of resource allocation to maximize net benefits. They found a four- to five-year pruning cycle was optimal, using the intersection of a marginal cost (loss of tree value with increased time since last pruned) and marginal return (money saved from delaying pruning activities; see Figure 3). As tree pruning is delayed, the condition rating of a tree decreased, resulting in the lower appraised tree value. Work by Browning and Wiant (1997) found that deferring utility tree pruning four years past the optimal pruning cycle (five years) yielded USD $1.47–$1.69 in costs for every one dollar deferred, and resulted in a two-fold increase in pruning debris. For utility pruning, the reliability of service is one important factor to consider when determining the optimal utility pruning cycle length [see the review of utility pruning literature by Goodfellow and Kayihan (2013)]. Recently, Ryder and Moore (2013) found that pruning trees at a young age (formative pruning) was less expensive than waiting to correct structural defects 20 years later.

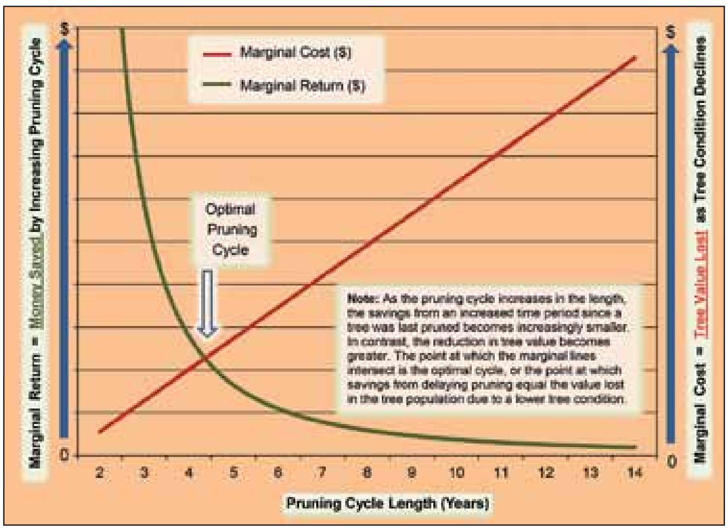

Figure 3. Marginal cost (loss of tree value) and marginal return (savings in pruning costs) for pruning cycle lengths used to determine an optimal pruning cycle at the point that marginal lines intersect (adapted from Miller and Sylvester 1981).

Watering During Tree Establishment

Water is a global resource, and it is becoming increasingly important that we use it wisely. Plant growth is limited by water availability, meaning inadequate water at critical plant life stages can ultimately lead to decreased tree health and death (Kozlowski and Pallardy 1997). Many articles talked about adequate watering to promote growth and health; however, few studies described the economics of watering. Gilman (2001) found that watering newly planted trees was less expensive than not watering trees when the costs of replacing dead (unwatered) trees was included in the total tree establishment costs. The lone exception was root-pruned balled-and-burlaped trees that displayed no difference in tree mortality between water and unwatered treatments. All watered trees, however, had greater growth.

Pests, Trees, Action

The cost of various levels of pest management intensity was illustrated between the 1960s and 1980s with the economics of controlling Dutch elm disease (DED, *Ophiostoma novo-ulmi*). Intensive sanitation (three annual surveys) to identify diseased trees to remove and slow the spread of DED was 25 percent less costly (Cannon and Worley 1976) and returned a higher benefit–cost ratio (Sherwood and Betters 1981) than conventional sanitation (one annual survey), which resulted in greater tree mortality. Miller and Schuman (1981) found that treating and preventing elms from dying returned the greatest net benefit compared to no control or poor DED control. Replanting removed trees returned the highest net value for the urban forest over a period of 40 years.

The management of ash (*Fraxinus* spp.) tree populations and emerald ash borer (EAB, *Agrilus planipennis*) is a current challenge. Management options generally involve four choices: 1) do nothing, 2) preemptively remove ash trees, 3) preemptively remove and replace ash trees, or 4) treat trees with an insecticide that prevents injury from EAB. All scenarios involve removing dead trees to alleviate tree risk. Treatment to prevent death or planting to replace removed trees is done to maintain tree benefits. Similar to the DED management scenarios of Miller and Schuman (1981), analysis of the four EAB management options by VanNatta et al. (2012) found that the net benefits of ash trees treated to prevent EAB infestation was always greater than doing nothing and waiting for tree death. Preemptive removal and replacement was the third best option, followed by preemptive removal and not replanting. Thus, both DED and EAB management analyses observed that when accounting for the costs of preventing urban trees from dying by insect or disease, the net benefit of treatment and replacement was greater than the cost of forgone benefits in limited or no-control scenarios.

Appropriate pest management can benefit from applying principles of economic and aesthetic action thresholds (Ball and Marsan 1991). A *threshold* is a point at which the losses exceed an acceptable level. Economic thresholds can use marginal analysis to decide when treatment should occur—when the costs of doing nothing surpasses the treatment cost.

A Model for Quantifying Costs and Benefits

Quantifying the elements of maintenance strategies is an important part of being able to link maintenance activities to system or tree performance in order to determine what is optimal or adequate maintenance.

More detailed information about the intensity, frequency, duration, and extent of different types of maintenance activities inform further analyses of the costs and benefits of maintenance. Practitioners could keep track of the precise intensity and frequency with which trees are maintained and the type of maintenance performed on these trees (e.g., pruning, inspection for hazards to determine whether removal is necessary), which would greatly enhance the ability to link maintenance strategies to tree outcomes (Figure 2). In addition, linking maintenance to measured tree structure and function parameters would clarify how tree growth and condition is affected. Tree diameter and condition are nicely linked to the outputs expressed as benefits. Linking costs to maintenance strategies could then help determine optimal levels of maintenance. The value derived would then be related to the cost used to obtain that value.

Strategies for Future Research

A minority of papers in this research explicitly included costs (36 percent; 59 of 163) as part of a study. Some papers inferred costs (21 percent; 34 of 163). Quantifying the costs associated with maintaining trees is an important first step towards quantifying the costs of not maintaining trees. This could be done by more strictly tracking costs (or inferring costs) using published findings. A standardized accounting approach (e.g., net benefits, benefit/cost, interest discounting to a specific period) would assist with quantifying costs to compare study and practitioner assessment of arboriculture and urban forestry.

Tree condition is often used as a proxy for tree health. While not a perfect relationship, the condition of a tree during any life stage affects the function and provision of benefits. As an example of linking tree condition and urban forest economics, the relationship with tree condition and years-since-last-pruned was demonstrated by Miller and Sylvester (1981). This fundamental and seminal paper needs quantification throughout climatic zones, with additional tree species groups, and tree life stages. Linking tree condition to tree physiology and ecosystem functions or services—such as net functional uptake (air pollutants), absorption (water and particulate matter), shading (energy conservation), and social desires (aesthetics)—would provide a way for practitioners to easily approximate tree condition and benefits.

Calculating the benefits of urban trees can be assessed easily with i-Tree or the Tree Benefits Calculator. Modeling of costs within these tools can provide a practical way to assess and make maintenance decisions regarding each of the six elements of tree maintenance. Understanding the costs of tree maintenance is an important part of evaluating whether monetary investments in the urban forest make economic sense. Making informed decisions necessitates including the costs of maintenance activities to see if they exceed, equal, or are lower than the benefits generated over time.

Conclusion

Several examples from the literature show that the cost of not maintaining trees results in a loss of net benefits from urban trees. Economic cost-to-benefit ratio or net benefit analyses allow for rational decisionmaking, and allow tree managers to ask if a tree care treatment makes economic sense. The value of benefits over time can be optimized by comparing maintenance costs incurred during that period to determine what level of maintenance provides the highest total net benefits.

Literature Cited

Ball, J., and P. Marsan. 1991. Establishing monitoring routines and action thresholds for a landscape IPM service. *Journal of Arboriculture* 17(4):88–93.

Browning, D.M., and H.V. Wiant. 1997. The economic impacts of deferring electric utility tree maintenance. *Journal of Arboriculture* 23(3):106–112.

Cannon, W.N., and D.P. Worley. 1976. Dutch elm disease control: Performance and costs. USDA Forest Service Research Paper No. NE-345. USDA Forest Service Northeastern Forest Experiment Station. 8 pp.

Gilman, E.F. 2001. Effect of nursery production method, irrigation, and inoculation with mycorrhizae-forming fungi on establishment of *Quercus virginiana*. *Journal of Arboriculture* 27(1):30–39.

Goodfellow, J.W., and A. Kayihan. 2013. Development of a business case for scheduling utility vegetation management on a preventative vs. corrective maintenance basis. TREE Fund Grant # 12-UARF-01, Phases I and II Final Report. Accessed 06/27/2014. <www.isa-arbor.com/events/conference/proceedings/2013/GOODFELLOW_UAA_UARF%20project%20update%20May%202013.pdf>

Kozlowski, T.T., and S.G. Pallardy. 1997. *Growth Control in Woody Plants*. Academic Press, San Diego, California, U.S. 641 pp.

McPherson, E.G., D. Nowak, G. Heisler, S. Grimmond, C. Souch, R. Grant, and R. Rowntree. 1997. Quantifying urban forest structure, function, and value: The Chicago Urban Forest Climate Project. *Urban Ecosystems* 1:49–61.

Miller, R.W., and S.P. Schuman. 1981. Economic impact of Dutch elm disease control as determined by computer simulation. pp. 325–344. In: E.S. Kondo, Y. Hiratsuka, and W.B.G. Denyer (Eds.). Proceedings of the Dutch elm disease symposium and workshop. October 5–9, 1981, Winnipeg, Manitoba. Manitoba Department of Natural Resources; Winnipeg, Canada.

Miller, R.W., and W.A. Sylvester. 1981. An economic evaluation of the pruning cycle. *Journal of Arboriculture* 7(4):109–112.

Roy, S., J. Byrne, and C. Pickering. 2012. A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening* 11(4):351–363.

Ryder, C.M., and G.M. Moore. 2013. The arboricultural and economic benefits of formative pruning street trees. *Arboriculture & Urban Forestry* 39(1):17–24.

Sherwood, S.C., and D.R. Betters. 1981. Benefit-cost analysis of municipal Dutch elm disease control programs in Colorado. *Journal of Arboriculture* 7(11):291–298.

VanNatta, A.R., R.H. Hauer, and N.M. Schuettpelz. 2012. Economic analysis of emerald ash borer (Coleoptera: Buprestidae) management options. *Journal of Economic Entomology* 105(1):196–206.

Richard J. Hauer is a professor of Urban Forestry with the College of Natural Resources at the University of Wisconsin–Stevens Point.

Jessica M. Vogt is visiting assistant professor with the Department of Earth & Environmental Sciences at Furman University.

Burnell C. Fischer is interim director to The Vincent and Elinor Ostrom Workshop in Political Theory and Policy Analysis, and clinical professor at the School of Public and Environmental Affairs, Indiana University, Bloomington.

An audio version of this article is available for download on the ISA website.

ARBORIST·NEWS Audio